

⑫ **EUROPEAN PATENT APPLICATION**

⑳ Application number: **84306420.5**

㉑ Int. Cl.⁴: **F 03 D 3/06**

㉒ Date of filing: **20.09.84**

㉓ Priority: **23.09.83 US 535099**

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㉕ Date of publication of application: **08.05.85**
Bulletin 85/19

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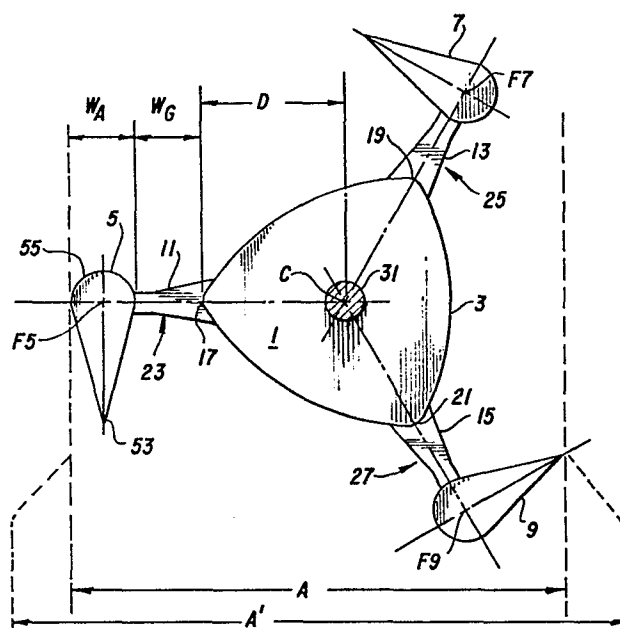
㉗ Designated Contracting States: **AT BE CH DE FR GB IT LI LU NL SE**

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㉙ **Rotor apparatus.**

㉚ A rotor apparatus for producing power from the rotation thereof comprising a support (31) and a central core (1) having a spherical triangular cross-section mounted on the support for rotation about a central axis through the core. Support arms (11, 11'; 13, 13'; 15, 15') fixed to the central core and extending radially outward therefrom at the vertices of the spherical triangle have airfoils (5, 7, 9) fixed to radially extended portions such that a gap (23, 25, 27) is formed between the surface of the central core and the surface of each airfoil, with the airfoils aligned on an axis parallel to the axis of the central core.

During rotation, fluid flow, such as air flow, having at least a component in the direction perpendicular to the axis of the central core, flows through the gaps producing a venturi effect which enhances the movement of the airfoils about the axis of the central core.



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ROTOR APPARATUS

The present invention is directed to a vertically oriented rotor apparatus and more particularly, to a rotor apparatus which comprises a vertically oriented rotatable central spoiler core having a spherical-triangular cross-section and three airfoils mounted on support arms extending from the verticies of the spherical triangle. The airfoil and central core are positioned with respect to each other such that there is a gap therebetween. The gap produces a venturi effect when air flows through the gap. Air flow around the structure and through the gap causes the movement of the airfoils which apply torque to the core through the support arms which rotates the core and the rotating of the core is used to generate power through a suitable power transmission. The power generated by the venturi rotor structure may thus be supplied to an electrical generator, pump, ships screw or any other device requiring a mechanical power input.

Devices such as windmills are known use air flow for the generation of power. Prior art windmills generally have a propeller type of structure having a plurality of blades or vanes which extend radially outward in a plane which is substantially perpendicular to the direction of air flow. Vertically oriented prior art devices, of this type, generally use Darrius or Davonius type rotors. The force of the air against the blades or vanes causes them to rotate and this rotation can be used through a mechanical coupling to provide a power output.

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Prior art devices of this type have the disadvantage that they do not efficiently generate power and during periods of low velocity air flow, they may not be able to provide sufficient power for any practical use whatsoever. In high velocity winds, these prior art devices do not operate because of turbulence created by the high velocity air. The primary disadvantage of this prior art type of windmill is that there is a physical limitation on the blade speed above which the machine will destroy itself. Furthermore, the dynamic capture area of the air flow is equivalent to the geometric capture area and, therefore, there is no enhancement of air mass flow through the device. Still further, these devices are very noisy as a result of blade-wind interference.

Another prior art type device for using wind to generate power is a streaming divider with a central core. Stream dividing is a different principle than stream collecting used in the present invention. Devices of this type are described in German Patent Nos. DE 30 03 270 C2 and DE-PS 604 333. The device disclosed in DE-PS 604 333 has a fixed central core and a plurality of blades surrounding the core. The air flow through the device produces only lift forces and, therefore, the device is inefficient. The device disclosed in DE 30 03 270 C2 has a rotatable core and two airfoils. Air flowing into the device is divided with most of the air following the path of least resistance. This air flow produces a low pressure in certain rear areas of the device which results in a lift force being applied to one of the airfoils. This lift force causes the rotation of the rotor and thereby the core.

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It is the primary object of the present invention to provide a rotor apparatus which is simple in structure and which is efficient in the generation of power.

5 It is another object of the present invention to provide a rotor apparatus which has a structure which permits it to utilize a venturi effect to enhance the efficiency of operation and the power output of the apparatus.

10 It is a further object of the present invention to provide a rotor apparatus which can operate under an extremely wide range of wind conditions including a wide range of wind speeds and wind from any direction.

15 It is still another object of the present invention to provide a rotor apparatus which is simple in construction, highly reliable, and which requires minimal maintenance.

The present invention is directed to a rotor apparatus for producing power from the rotation thereof. The apparatus comprises a support means and a central core means having a spherical triangular cross-section mounted on the support means for rotation about a central axis through the core means. A plurality of support arms, fixed to the central core means, extend radially outward therefrom at the vertices of the spherical triangle. At least three airfoil means are fixed to a radially extended portion of the support arms such that a gap is

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formed between the surface of the central core means and the surface of the airfoil means, with the airfoil means being aligned on an axis parallel to the axis of the central core means. Fluid flow, such as air flow, having at least a component in the direction perpendicular to the axis of the central core means flows through the gap producing a venturi effect for enhancing the movement of the airfoil means about the axis of the central core means. The movement of the airfoil means applies torque to the central core means through the support arms to thereby rotate the central core means. The central core means includes an output means which rotates with the central core means and which can be used as a power takeoff from the rotating central core means.

The airfoil means can be either fixedly mounted or pivotally mounted on the support arms. Further, the venturi rotor can be vertically oriented so that it will be rotated in response to wind from any direction. Still further, the central core means and the airfoil means can be made from a plurality of modular units to provide for the simple construction of devices of various sizes.

Figure 1 is a plan view of a venturi rotor,

Figure 2 is a front view of a venturi rotor,

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Figure 3 is a cross-sectional view of the central core of the preferred embodiment,

Figure 4 is a cross-sectional view of an airfoil of the preferred embodiment, and

5 Figures 5A, 5B and 5C, illustrate an airfoil of an alternative embodiment.

Referring to the drawings, the venturi rotor structure is vertically oriented and comprises a rotatable central spoiler core 1 which has a spherical triangular cross-section 3. Three airfoils 5, 7 and 9 are fixed to the central core 1 by means of support arms 11, 11', 13, 13' and 15, 15'. The support arms extend radially outward from the central core 1 at the verticies 17, 19 and 21 of the spherical triangle 3. Gaps 23, 25 and 27 are formed between the verticies of the central core 3 and the airfoils 5, 7 and 9.

The shaft 31, which is part of the central core structure, extends along the central axis C of the central core 1. The rotation of the central core 1 rotates the shaft 31, which provides a power output through transmission 33, which is supported on a base 35. The transmission 33 could be a gear transmission, belt transmission, 5 hydraulic transmission, or any other suitable means for producing a power takeoff from a rotating shaft. The axes F5, F7 and F9 of the airfoils 5, 7 and 9, are parallel to the axis C of the central core.

25 The venturi rotor structure is supported by support posts 37, 39 and at least one additional post (not shown), which

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are connected to the central core by means of a superstructure 41. The central core 1 rotatably held and supported by the superstructure. Guy wires may also be used in lieu of or in conjunction with the support posts for providing a stable support structure for the apparatus.

Referring to Figure 3, the central core structure 1 has an outer portion 43 having a spherical-triangular cross-section and an inner portion 45 having a circular cross-section. The inner and outer portions are rigidly connected together by means of a plurality of ribs 47. The interconnected inner and outer core structure, provides a strong, rigid, lightweight central core. The inner and outer cores are connected to the central shaft 31 by means of an interconnecting structure 49.

Referring to Figure 4, the airfoils 5, 7 and 9 each have a leading edge 53, which is a knife edge and a trailing edge 55, which is circular ^{in cross section.} The maximum width of each airfoil w_A is approximately equal to the width of the gap w_G between the airfoil and the central core. Further, the width of the gap and the maximum width of each airfoil, $w_A + w_G$, is equal to the distance D from the central axis C of the central core to the vertices of the central core. In the preferred embodiment, the vertices of the central core are slightly rounded with respect to the actual geometric vertices. There is thus, a small variation in the distances as shown in the drawings because of this difference. Further, the distance from the axis of each airfoil to its leading edge is such that a line L extending between the leading edge and the adjacent vertex of the central

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core is parallel to the line M between the axis C and the axis of the airfoil.

With reference to Figure 1, in operation, the core 1 functions as a barrier to the wind stream W directed toward the venturi rotor. The central core 1 thus directs the air in the capture area A' towards the airfoil and into the gap 23 between the airfoil 5 and the core 1. The flow of air through the gap 23 produces a venturi effect and the directing of the air flow in this manner results in a combination of effects which enhance the rotation of the venturi rotor, thereby producing a simple and efficient generation of power.

The directing of the air flow against the airfoil 5 produces a high pressure or drag on the front surface of the airfoil 5 which pushes the airfoil in the direction of the wind, thereby producing a torque on the central core 1 through the support arm 11. The torque rotates the central core 1. Simultaneously, air flow through the gap 23 has a venturi effect. This venturi effect cause an increase in air velocity through the gap which results in a substantial increase in the dynamic pressure in the area adjacent the gap and a very substantial decrease in the static pressure in this area. Dynamic pressure results in forces in the direction of flow and static pressure results in forces perpendicular to the direction of flow. The venturi effect thus creates a very low static pressure on the rear or downwind side of the central core 1 and on the opposite or rear surface of the airfoil 5. Thus, very low static pressure produces a lift effect which sucks or pulls the airfoil 5 and the

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core 1 in the direction of rotation resulting in additional torque being applied to the core 1, thereby enhancing the rotation of the core.

5 The venturi effect of the gap 23 causes an increase in the velocity of air flow through the gap and a decrease in pressure in and behind or downwind of the gap 23. The air flow through the gap 23 is thus enhanced first, due to the barrier effect of the central core 1 and secondly, due to the air flowing from the high pressure front side to the low pressure rear side.

10 The kinetic energy transferred from the air flow to the venturi rotor is a function of the mass of air flow in accordance with the equation

$$P = 1/2 mv^2$$

where:

15 P = power
m = mass of air
v = velocity of air flow

As can be seen from the above equation, the power can be increased by increasing the mass of air flow. The mass of air flow can be increased by an increase in the capture area of the venturi rotor. In the ^{present} apparatus, the low pressure area in the gap 23 and behind the central core 1 and the airfoil 5 caused by the venturi effect expands the dynamic capture area A' so that it is significantly larger than the geometric capture area A because the low pressure in effect,
25 sucks air from beyond the geometric capture A in order to fill the low pressure areas behind the venturi gap.

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In the positioning of the airfoils with respect to the wind direction as shown in Figure 1, the forces due to lift and drag on each of the airfoils 7 and 9 are such that the resultant force on each of the airfoils is negligible with respect to the forces on airfoil 5. Thus, with the airfoils in the position shown in Figure 1, the torque for rotating the central core 1 is produced as a result of the various forces on the airfoil 5 alone without any substantial contribution or degradation due to airfoils 7 and 9.

As the venturi rotor structure rotates, the various drag and lift forces as well as the areas of high and low pressure around the surfaces of the airfoils and central core is constantly changing. However, the resultant forces on the structure itself, which cause the rotation, remain relatively constant.

Figures 5A, 5B, 5C illustrate an alternative embodiment in which the airfoils are pivotally mounted on the support arms. Referring to Figures 5A, 5B, 5C, the airfoil 105 is mounted on the support arms 11 and 11' by means of a rotatable shaft 107. A spring 109 is connected to the shaft 107 through a hole 111 and engages the arm 11 to bias the leading edge 53 of the airfoil in a direction towards the central core. As the apparatus rotates, centrifugal force tends to push the leading edge of the airfoil away from the central core. The centrifugal force is counteracted at least to some extent by the biasing force of the spring to thereby optimize the airfoil orientation. Means such as stops, can be provided for limiting

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the pivotal movement of the airfoil with respect to the arms.
Preferably, total movement should be limited to 120°.

This embodiment is very effective in environments where wind speed is relatively constant because the spring constant can be selected for a particular angular speed. If there is a large variance in wind speed, then the fixed airfoil embodiment is more effective. Other techniques for adjusting the orientation of the air foil can also be used.

The central core 1 and/or the airfoils 5, 7 and 9 may be constructed as unitary structures or maybe made of a plurality of modular units rigidly fastened together. Referring to Figure 2, the central core 1 is formed of a plurality of modular units 1A...1E, which are rigidly fastened together by any suitable means such as welding, bolting, riveting, etc. Further, the airfoils 5 and 9 are also constructed of a plurality of modular units 5A...5E and 9A...9E. These units are also rigidly fastened together by any suitable means. The advantage of the modular construction is that it enables an apparatus of any size to be easily constructed using standard modules. This permits greater flexibility in the manufacture and construction of the apparatus.

In selecting the materials for the central core and airfoils, a material should be chosen which has a high strength so that the apparatus can withstand high wind speeds. Furthermore, the material should be lightweight in order to minimize the centrifugal force resulting from the rotation of the apparatus.

Although in the preferred embodiment, the apparatus is disclosed as being driven by air flow caused by wind, it can be

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seen that the structure can be used with any type of fluid flow, either gaseous or liquid.

The present invention may be embodied in other specific forms without departing from the spirit or essential
5 characteristics thereof. The presently disclosed embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims, rather than the foregoing description, and all changes which come within the meaning and range of
10 equivalency of the claims are, therefore, to be embraced therein.

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CLAIMS

1. A rotor apparatus for producing power from the rotation thereof, the apparatus comprising a central airfoil carrying core means (1) mounted on a support means (31) for rotation about a central axis through the core means; characterised in that there is a plurality of support arms (11,11';13,13';15,15') fixed to the central core means (1) and extending radially outward therefrom; and at least three airfoil means (5,7,9) fixed to a radially extended portion of respective support arms (11,11';13,13';15,15') such that a gap (23,25,27) is formed between the surface of the central core means and the surfaces of each of the airfoil means, each of the airfoil means being aligned on an axis parallel to the axis of the central core means; wherein during rotation of the rotor apparatus fluid flow having at least a component in a direction perpendicular to the axis of the central core means flows through at least one of the gaps producing a venturi effect for enhancing the movement of the airfoil means about the axis of the central core means, this movement of the airfoil means applying torque to the central core means through the support arm thereby to rotate the central core means.
2. A rotor apparatus as claimed in claim 1, wherein the central core means (1) has a spherical-triangular cross-section, the support arms (11,11';13,13';15,15') radially extending from the verticies thereof.
3. A rotor apparatus as claimed in claim 2, wherein the central core means (1) has an inner, circular cross-section, core portion (45) and a spherical-triangular cross-section outer portion (43), these inner and outer portions being rigidly connected together.
4. A rotor apparatus as claimed in claim 1, 2 or 3, wherein the leading edge (53) of each airfoil means (5,7,9) is narrower than the trailing edge (55) thereof.

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5. A rotor apparatus as claimed in claim 4, wherein the leading edge (53) of each airfoil means (5, 7, 9) is a knife edge.

6. A rotor apparatus as claimed in claim 4 or 5, wherein the trailing edge (55) of each airfoil means (5, 7, 9) is an arcuate edge.

7. A rotor apparatus as claimed in any one of the preceding claims, wherein the support arms (11,11'; 13,13';15,15') extend from both ends of the central core means (1).

8. A rotor apparatus as claimed in any one of the preceding claims, wherein the central axis of the central core means (1) is vertical.

9. A rotor apparatus as claimed in claim 2, and any one of claims 3 to 8, wherein the width of each said gap (23, 25, 27) is substantially equal to the maximum width of each airfoil means (5,7,9).

10. A venturi rotor apparatus as claimed in claim 2, and any one of claims 3 to 9, wherein the width of each said gap (23,25, 27) and the maximum width of each airfoil means (5,7,9) is equal to the distance from the central axis to the vertices of the airfoil means.

11. A rotor apparatus as claimed in claim 2, and any one of claims 3 to 10, wherein a line from the leading edge of one of the airfoil means (5,7,9) to the adjacent vertex of the central core means (1) is parallel to a line from the central axis of the central core means to the axis of this airfoil means.

12. A rotor apparatus as claimed in any one of the preceding claims, wherein each airfoil means (5,7,9) is pivotally mounted on respective support arms (11,11';13,13';15,15').

13. A rotor apparatus as claimed in claim 12, wherein each airfoil means (5,7,9) includes means (109) for biasing the airfoil means against centrifugal force resulting from the rotation of the apparatus.

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14. A rotor apparatus as claimed in claim 13,
wherein the central core means (1) comprises a
plurality of modular units (1A 1E) rigidly coupled
together; and wherein each airfoil means (5,7,9)
5 includes a plurality of modular units (5A5E;
7A....7E; 9A....9E) rigidly coupled together.

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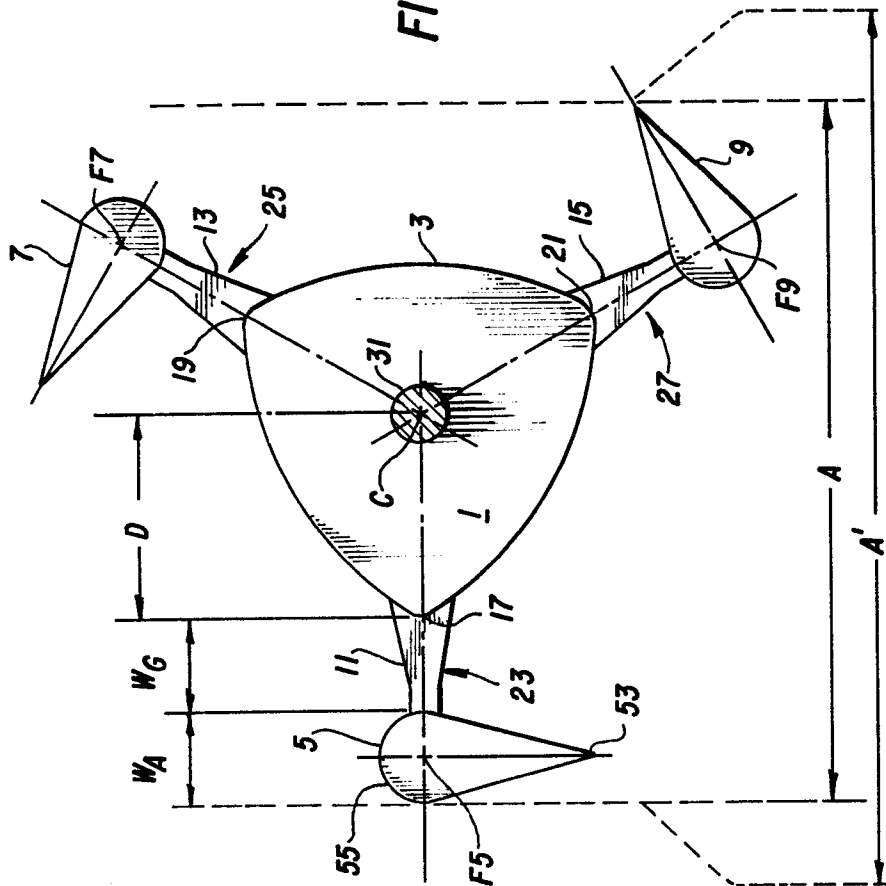
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FIG. 1



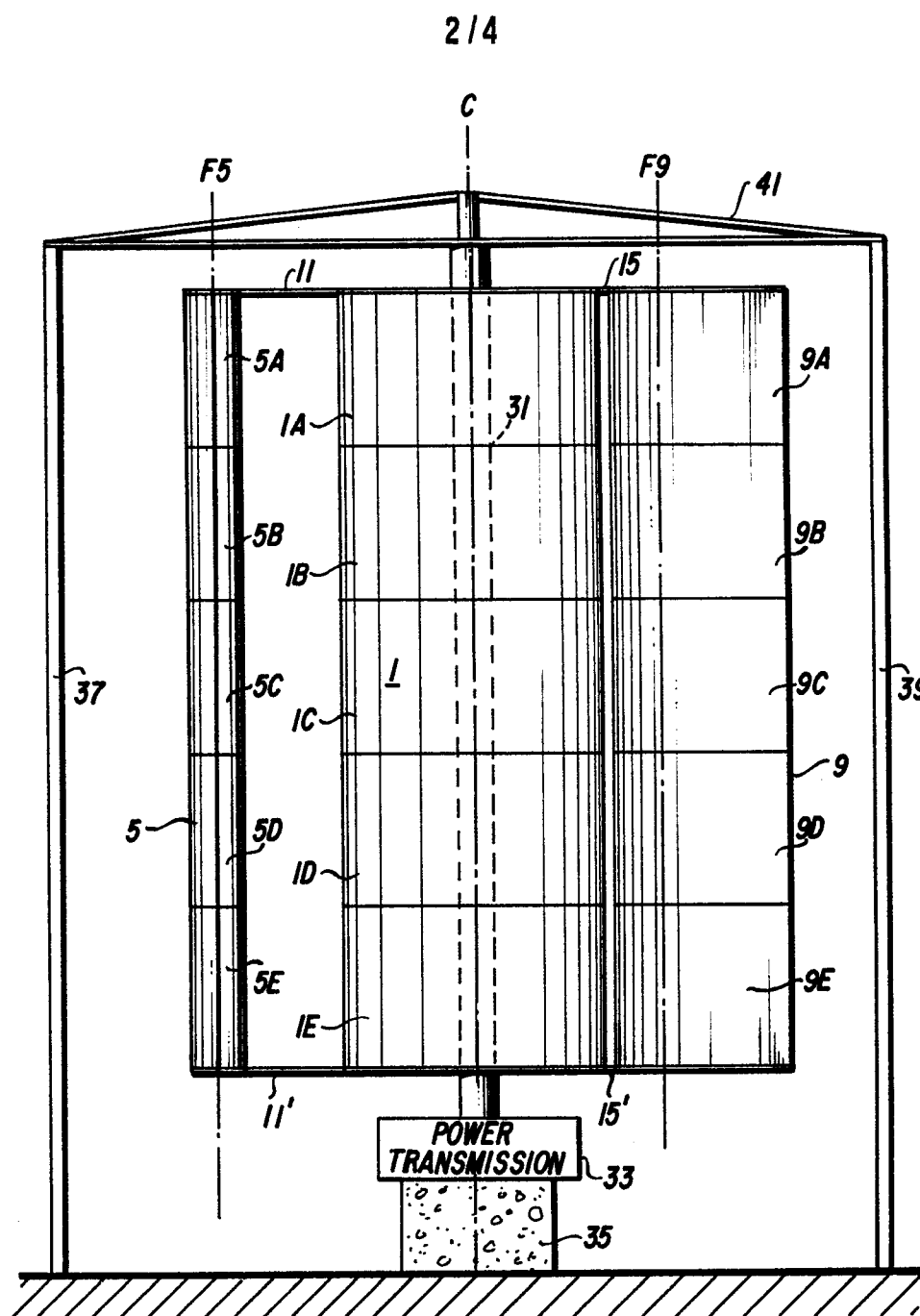
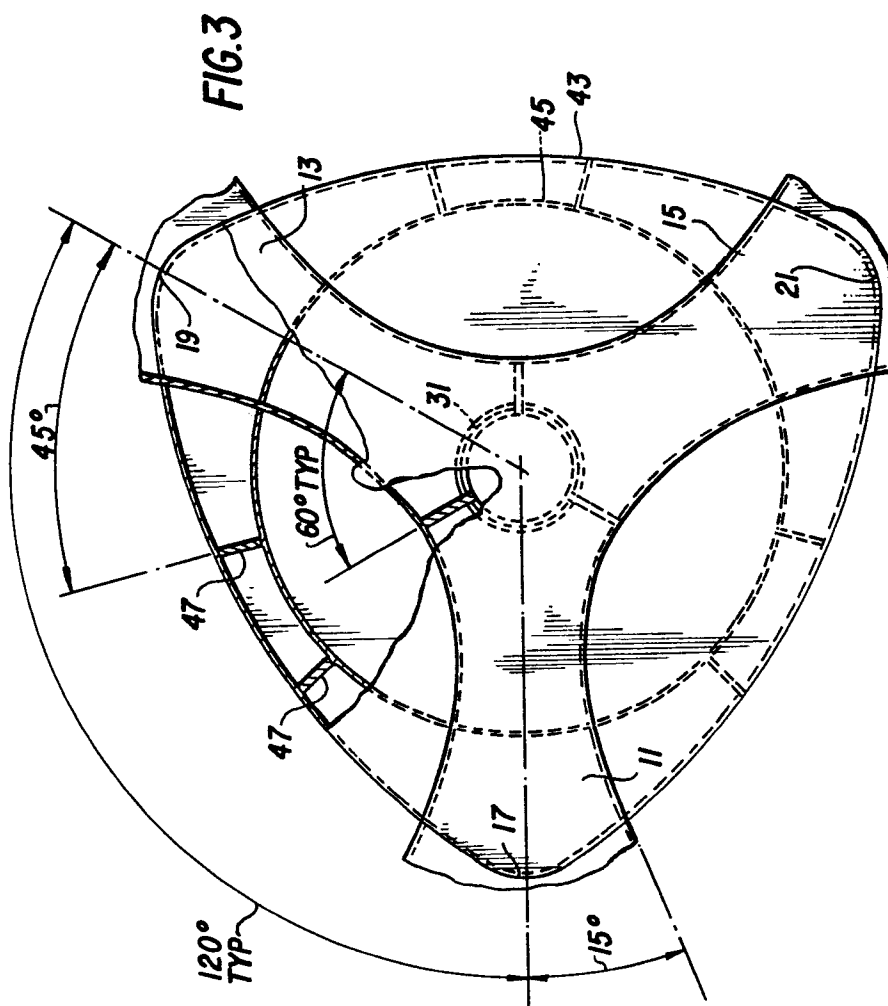


FIG. 2

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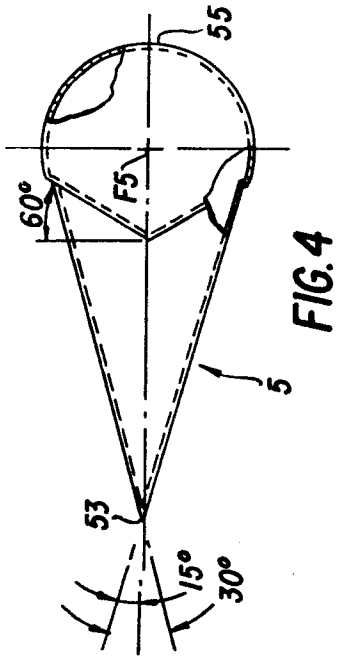


FIG. 4

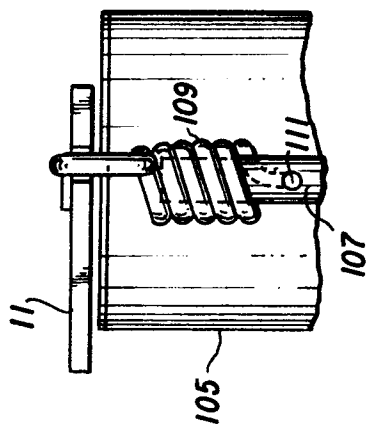


FIG. 5B

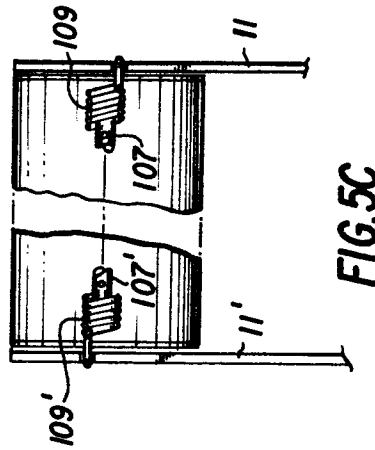


FIG. 5C

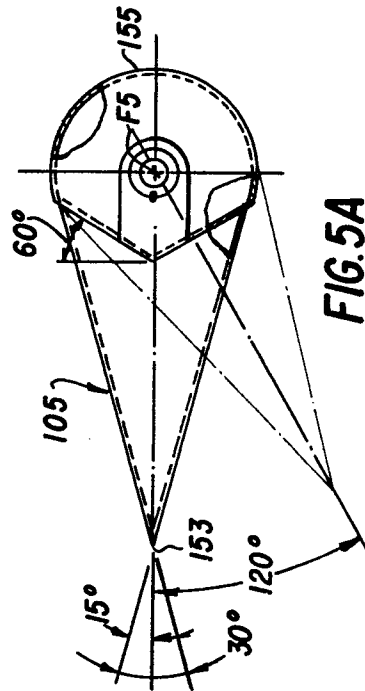


FIG. 5A

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European Patent
Office

EUROPEAN SEARCH REPORT

Application number

EP 84 30 6420

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
Y,D	DE-A-3 003 270 (A. GOEDECKE) * Page 4, lines 25-31; page 8, line 31 - page 9, line 11; figures 1-4 *	1,4-8, 12	F 03 D 3/06
Y	DE-A-3 004 669 (E. HERTER) * Figures 1,2; page 7, lines 1-5 *	1,4-8, 12	
A	FR-A- 929 721 (D. GUAL) * Figures 1,20 *	14	
A	FR-A- 732 018 (G. LEON)		
A,D	DE-C- 604 333 (H. HOFFMANN et al.) -----		TECHNICAL FIELDS SEARCHED (Int. Cl. 4) F 03 D
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 21-12-1984	Examiner THIBO F.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			